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# GaN half-bridge integrated circuits for power converters

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At AMICSA 2021 & 2022, first results of an integrated IC containing GaN half bridge & their associated drivers have been presented.

First GaN Half-bridges were developed and tested in the frame of SloGaN VLAIO project (Flemish regional funding). The aim was to achieve very first integration of high voltage & high current transistors with low voltage control & gate drive devices.

## GAN-IC4S ESA GTSP program

Deeper de-risking results originate from an ESA GAN-IC4S program where IMEC has partnered with MinDCet (IC design house) & Thales Alenia Space for the development of a single chip half bridge with integrated pre-drivers. The IC is designed on IMEC's GaN on SOI & high voltage (200V) process.

The run2 fixing some issues was tested in Q1 & Q2 2023. A dc-dc converter was built to demonstrate electrical performances and finally the same dc-dc was exposed to heavy ions showing excellent robustness of this technology.

The component includes follow features:

- High-side and low-side, high current (22 mOhms) P-GaN HEMT
- Integrated high-side & low-side gate drivers
- Temperature sensing
- Gate driver voltage regulation
- Isolated level-shifter for gate control signal propagation to floating levels
- Dead-time generator

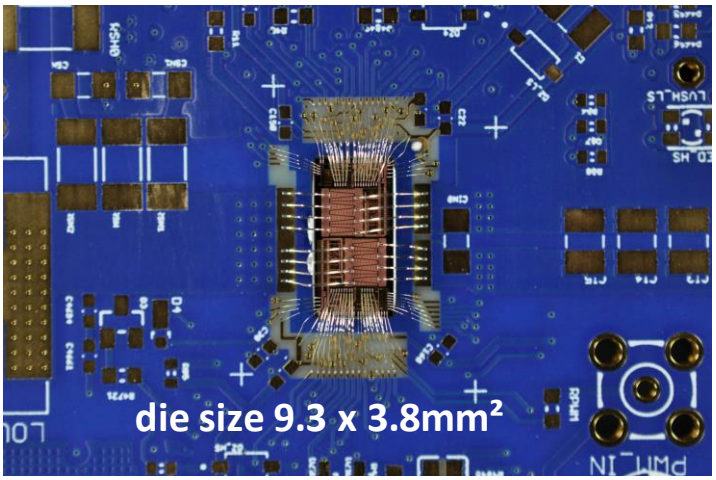


**Figure 1** P-GaN HEMT Half-bridge 2x 22mOhm 200V with integrated drivers

Clearly this IC is a breakthrough and the key enabler is the GaN on SOI technology developed by IMEC. This technology allows to co-integrate several devices on the same die using deep trench isolation. Although the co-integration of high-side & low-side power devices sounds straightforward, practical parasitic substrate capacitances often cause the exercise to fail.

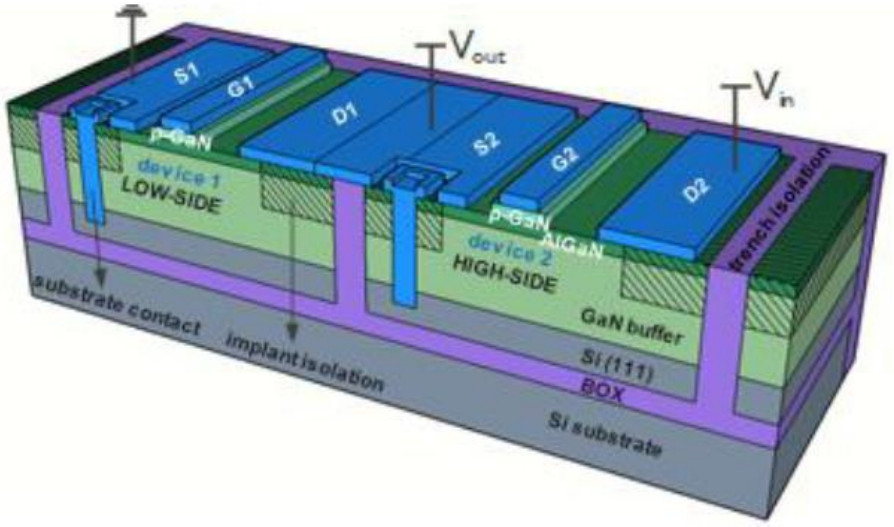


**Figure 2** Cross-section of monolithic integration of HS and LS switch

Second step is a full feature 3..8A 200V integrated GaN IC Half-bridge been developed under ESA GSTP program. Figure 3 shows the IC prototype in a true dc-dc converter.

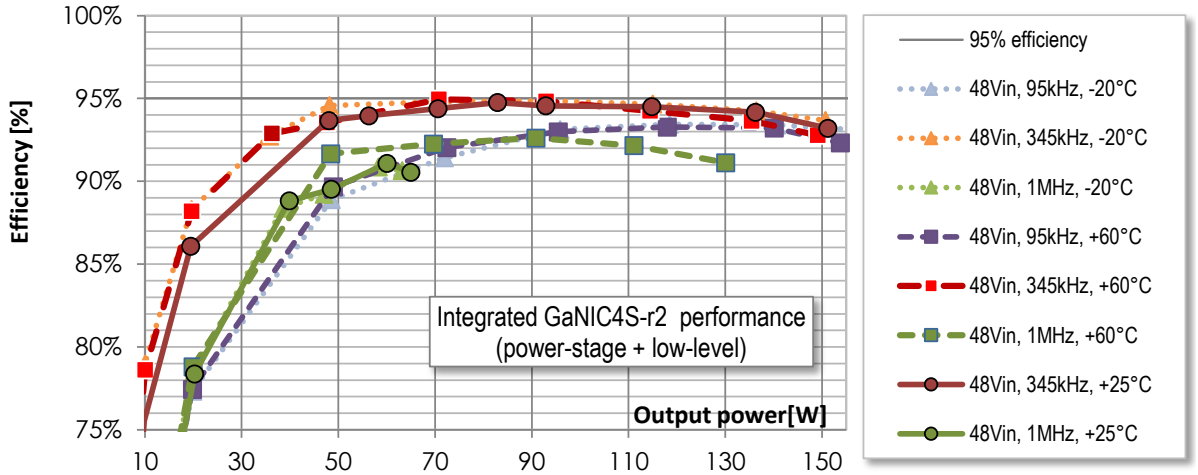


**Figure 3: dc-dc converter with GaN integrated half-bridge**

## EleGaNt European Commission H2020 Space work program

Latest developments are now ongoing in the European Commission H2020 Space project called EleGaNT. The same consortium, extended with the partner Wurth Electronics, aims at exploiting GaN based technology for applications relevant in low voltage combined with high current. The goal of ELEGANT is on one hand developing and maturing a fully EU based, normally-off 100V GaN process for space applications and, on the other hand, designing and manufacturing a point of load converter based on GaN integrated half-bridges and new magnetic components, space qualified.

This PoL converter aims at delivering 75 A current at low voltage output (down to 0.7V) in order to supply high complexity integrated circuits like FPGA or processors. With advancement of technologies and extended chip functionalities, transistor size is shrinking, while power consumption [watts] remains similar to previous generations. The result is an increased demand for lower & lower supply voltages combined with higher & higher currents. It is common view that that GaN technology is a good candidate to satisfy those needs as it can offer lower Rdson than silicon, lower intrinsic capacitance, higher switching frequencies combined with an inherently higher radiation robustness.

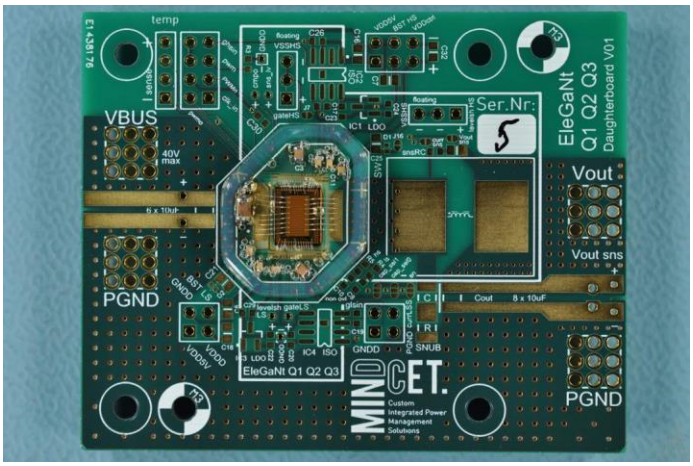


**Figure 4.** P-GaN HEMT Half-bridge 8 & 13 mOhms

Two IC runs have been processed in IMEC's fab on the basis of the 100V GaN process optimized for responding to space requirements. The design exercise was clearly a race to squeeze the design as much as possible chasing any fraction of mOhms. As a result, the half-bridge combines 13 mOhms high side & 8 mOhms low side in 7 x 3mm power cell.

Point-of-load converter tests are ongoing and the results will be presented at the conference in May 2024.

Next to that, we have taken advantage of this de-risking foundry run to integrate as much as possible regulation features. The IC contains operational amplifiers, high comparators, level shifters, current sensing amplifiers. These are quite experimental features considering that the relevant GaN process does not offer complementary devices: currently only normally-off HEMT (N-ch like) devices & resistors can be used.

## Acknowledgments

1. Project SloGaN System Level Optimization of GaN-based power devices funded by Agenschap Innoveren & Ondernemen (VLAIO) and ICON https://www.imec-int.com/en/what-we-offer/research-portfolio/slogan

2. Project GANIC4S Monolith ic integration of GaN gate driver and power transistor switching functions under ESA Contract No.4000128515/19/NL/FE

3. Project EleGaNT: high current low voltage point of load converter based on GaN integrated half-bridges. https://cordis.europa.eu/project/id/101004274